HYDROLOGY

Precipitation

Average annual precipitation for the Niangua Watershed is 40-42 inches per year (MDNR, 1986). The mean monthly precipitation at the Buffalo weather station, which is located near the center of the watershed, is shown in Figure 7. The wettest months are typically May, June, and September and the driest are December, January, and February.

Gaging and Water Quality Stations

Gaging and water quality stations are listed in Table 8 and mapped in Figure 8. There have been six (United States Geological Survey) gaging stations and two low flow stations in the Niangua Watershed. In addition, 19 water quality stations and one gaging station were monitored by the USGS for the Upper Niangua Animal Waste Project (UNAWP) between 1991 and 1995. Five water quality stations were monitored in 1989 and 1990 by a private contractor, Environmental Science and Engineering (ESE), to satisfy Federal Energy Regulatory Commission (FERC) requirements for Tunnel Dam relicensing (ESE, 1990). Sho-Me Electric Corporation helped fund the installation and maintenance of a new gaging station in November 1995 immediately below Tunnel Dam (NR) to monitor flow.

Stream Flow

The most downstream USGS station on the NR near Decaturville (G026) indicated a median flow of 325 cfs between 1929 and 1969. The drainage area for this station is 627 square miles. A flow duration curve for the Decaturville station is shown in Figure 9. The low 10:90 ratio (ratio of the discharge exceeded 10% of the period of record to that exceeded 90% of the period of record) of 8.8 indicates that flows are not highly variable. This value is at the low end of the range exhibited at other stations with similar drainage areas throughout the state (Skelton, 1976). Although no quantitative data is available, the median flow of the LNR as it enters the lake is usually noticeably less than that of the NR. The most downstream station on the LNR, near Macks Creek (G025), was operated as a low flow and crest station between 1962 and 1971 so median flow is not available. The only continuous record station in the LNR watershed was on Starks Creek (G024), a third order tributary. The Starks Creek flow duration curve (Figure 10) with a 10:90 ratio over 400 indicates highly variable flows at this station. This station is in the headwaters of Starks Creek (SM 12) where the average gradient is 30.8 feet per mile.

The magnitude and frequency of low-flows at several stations in the watershed are shown in Table 9. The low flow is the lowest average flow over a 7-day period that is likely to occur during a given recurrence interval. These can be useful for evaluating the impacts of effluent discharges or water withdrawals and droughts during critical periods of low flow. In Missouri low flows usually occur during August, September, and October (Skelton, 1976). Skelton also explained that Ozark streams usually have the best sustained low flows in the state, due to large underground reservoirs in the solution dissolved carbonate bedrock. However, solution channels can also divert groundwater before it reaches streams, and drain surface water from losing streams in some areas. In many of the watershed's streams, considerable water flows in the gravel beneath the stream bed during drought. Fourth order and larger reaches of most tributaries sustain permanent flow throughout the year. Maximum and minimum discharges for four

Figure 07. Mean monthly precipitation at Buffalo, Missouri between 1930 and 1995.

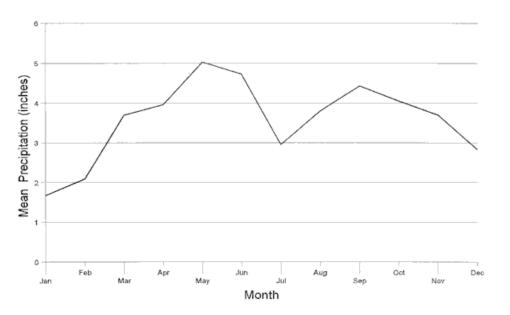


Figure 8. Gaging and water quality stations within the Niangua River Watershed.

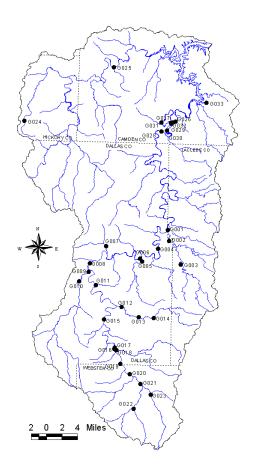


Table 8. Water quality and gaging stations within the Niangua Watershed.

Site Number	Station Number	Station Name	Location	Period of Record	Drainage Area (mi ²)	Type of Station ³
G001	06923700		Lat 37º44'17" Long 92º51'37" SESE S25,35N,18W at bridge on Hwy 64	'82-'88 '91- Date		WQonly
G002	06923500	Bennett Spring	Lat 37°43'03", 92°51'26"NW S1,34N,18W;1 mile upstream Niangua R	'16-'20 '28-'41 '65-'95	100	Contin.
G003	06923400	Spring Creek above Bennett Spring	Lat 37°40'22" Long 92°49'47" SESW S8,34N,17W	'91-'95		WQ only
G004	06923300	Niangua River above Bennett Spring	Lat 37°42'07" Long 92°52'53" NWSW S2,34N,18W	'91-'95		WQ only
G005	06923255	Four Mile Creek near Windyville	Lat 37 ⁰ 40'41" Long 92 ⁰ 55'11" NWSW S9,34N,18W at Hwy P	'91-'95		WQ only
G006	06923250	Niangua River at Windyville at Hwy K	Lat 37°41'03 Long 92°55'27" NWSENE S8,34N,18W	'54,'67,'71 '75,'76.'80 '91-Date	377	Contin.
G007	06923242	Durington Creek near Wood Hill	Lat 37°42'27" Long 93°00'15 NESW S3,34N,19W	'91-'95		WQ only
G008	06923240	Niangua River near Buffalo	Lat 37°40'30" Long 93°02'27" NENW S17,34N,19W	'91-'95		WQ only
G009	06923237	Greasy Creek below Buffalo	Lat 37°39'33" Long 93°02'41" NW S20,34N,19W	'91-'95		WQ only
G010	06923235	Greasy Creek at Hwy 32 near Buffalo	Lat 37°28'27" Long 93°04'03" SWNW S30,34N,19W	'91-'95		WQ only
G011	06923200	Niangua River at Hwy 32 near Buffalo	Lat 37°38'04" Long 93°01'39" SW S28,34N,19W	'91-'95		WQ only
G012	06923150	Dousinbury Creek on JJ near Wall Street at downstream edge of bridge	Lat 37°35'38" Long 92°58'00" SWNE S12,33N,19W	'91- Date	35.7	Gaging & WQ

G013	06923140	Dousinbury Creek near Long Lane	Lat 37°34'28" Long 92°55'42" SE S17,33N,18W	'91-'95		WQ only
G014	06923135	Dousinbury Creek near Earnestville	Lat 37°34'50" Long 92°53'34" SE S15,33N,18W	'91-'95		WQ only
G015	06923130	Niangua River near Spring Grove	Lat 37°34'13" Long 93°00'28" NW S22,33N,19W	'91-'95		WQ only
G016	06923120	Niangua River near Charity	Lat 37°31'12" Long 92°58'59" SE S2,32N,19W	'91-'95		WQ only
G017	06923110	Johnson-Wilkerson Spring near Charity	Lat 37º31'08" Long 92º59'01" NWSE S2,32N,19W	'91-'95		WQ only
G018	06923100	Jones Creek near Charity	Lat 37°30'50" Long 92°58'46" NENE S11,32N,19W	'91-'95		WQ only
G019	06923088	Jake George Spring near Thorpe	Lat 37°29'20"Long 92°58'09"NWSE S31,32N,19W	'91-'95		WQ only
G020	06923070	Niangua Riverbelow Forkners Hill	Lat 37°28'08"Long 92°56'58"NE S30,32N,18W	'91-'95		WQ only
G021	06923060	Niangua River on Hwy Y	Lat 37°27'01" Long 92°55'25" SWNW S33,32N,18W	'91-'95		WQ only
G022	06923050	West Fork Niangua River near Bermott	Lat 37º24'16" Long 92º56'37" NWSW S17,31N,18W	'91-'95		WQ only
G023	06923040	East Fork Niangua River near Samson	Lat 37°25'48" Long 92°54'00" NESESW S3,31N,18W	'91-'95		WQ only
GO24	069252001	Starks Creek 1 mi east of Preston	Lat 37056'27" Long 93011'48" SWNW S24,37N,21W at Hwy 54 bridge	'56-'78	4.18	Contin.

G025	069252501	Little Niangua River near Macks Creek	Lat 38°02'30" Long 92°59'05"N S14,38N,19W; Co Rd N-165, at Bannister Ford	'62-'71	338	Low &Crest
G026	069240001	Niangua River near Decaturville	Lat 37°56'20" Long 92°50'30" NWNE S19,37N,17W	'29-'69	627	Contin.
G027	06923950	Niangua River at Tunnel Dam near Macks Creek	Lat 37°56'13" Lomg 92°51'05" SWNWNW S19,37N,17W	'95- Date		Contin.
G028	WQ1 ²	Niangua River First riffle upstream from Lake Niangua	Lat 37°55'17" Long 92°52'25" SENE S26,37N,18W	'89-'90		WQ only
G029	WQ2A ²	Lake Niangua Mid-channel, approx.~ 200' upstream of Dam	Lat 37º56'10" Long 92º51'01" SWNW S19,37N,17W	'89-'90		WQ only
G030	WQ2B ²	Lake Niangua Upper Portion of Lake	Lat 37°55'23" Long 92°52'27" NWNE S25,37N,18W	'89-'90		WQ only
G031	WQ3 ²	Niangua River Hwy U bridge approx.~ 2 midownstream of Dam	Lat 37º56'19" Long 92º52'27" NENE S23,37N,18W	'89-'90		WQ only
G032	WQ42	Niangua River~100yds downstream from powerhouse discharge from Lake Niangua	Lat 37°56'18" Long 92°50'47" NENW S19,37N,17W	'89-'90		WQ only
G033	06924500	Ha Ha Tonka Spring at Ha Ha Tonka State Park	Lat 37°58'26" Long 92°45'04" SENW S2,37N,17W	'23-'25 '64-'66,'71 '93-Date		WQ only
G034	06923000	Niangua Branch at Marshfield	Lat 37E20'50" Long 92E54'45" SENE S4,30N,18W	'51-'58 '60-'79	0.82	Gaging

¹ Discontinued United States Geological Service USGS stations.

² Environmental Science & Engineering, Inc. 1990. Niangua River Water Quality and Fisheries Survey. Prepared for BVMCA, Kansas City, MO.

³ All stations are USGS operated unless otherwise indicated.

WQ - Stations at which periodic water quality measurements are made.

Contin - Stations at which continuous discharge measurements are made.

Low flow - Stations at which discharge measurements were made only during low flow periods.

Gaging- Stations at which discharge measurements were made on a daily basis.

Crest- Stations at which peak discharge are recorded for a given time interval.

Table 9. Magnitude and frequency of annual low-flows for select stations within the Niangua Watershed (Skelton, 1976).

Site Number	Station Number	Station Name and Location	Station Name and Location Period of Record		Period (days)	Annual Low-Flow (cfs) for Indicated Recurrence Interval					
				(mi ²)		2	5	10	20	50	
G011	06923200	Niangua River near Buffalo, Dallas County	'54, '62-'65, '70		7	17.0		8.0			
G002	06923500	Bennett Spring at Bennett Spring State Park, Dallas County	'16-'20, '28-'41, '65-'72		7	80.0		62.0	57.0		
G033	06924500	Ha Ha Tonka Spring at Ha Ha Tonka State Park, Camden County	'23-'25, '64-'66, '71		7	48.0		40.0			
G024	06925200	Starks Creek at Preston, Hickory County	['] 58-'72	4.18	7	0	0	0	0	0	
G006	06923250	Niangua River near Windyville, Dallas County	'54	377	7		14.1				
G025	06925250	Little Niangua River near Macks creek, Camden County	 		7	10.0		3.6	2.8		

Figure 09. Flow duration curve for the Niangua River near Decaturville (G024).

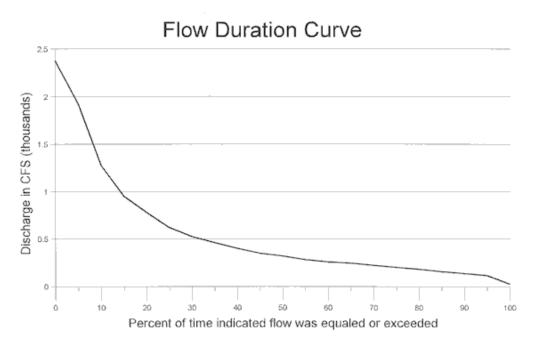
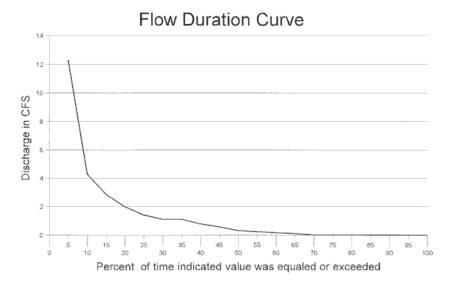


Figure 10. Flow duration curve for Starks Creek near Preston (G024).



gaging stations are shown in Table 10. Small streams in the watershed are flashy, with high flows after significant rainfall. Flood discharges at gaging stations with sufficient data are shown in Table 11.

Springs

The Niangua Watershed contains numerous springs (Table 12; Figure 11). Some of the springs listed in Table 12 were found in historical records (Skinner, 1979) or on 7.5 minute topographic maps so their current status is unknown. Skinner (1979) reported that many strong flowing springs went dry following agricultural development in the watershed. Some landowners have also reported that small permanent springs have ceased flowing in the last 50 years (Bob Schulz (MDC), pers. comm.). The largest springs in the watershed are Bennett Spring, the fourth largest in Missouri, and Ha Ha Tonka Spring, the twelfth largest in the state (Vineyard and Feder, 1982). Bennett Spring practically doubles the flow where it joins the NR at SM 65.9. Bennett Spring is supplied by an extensive recharge area (Figure 11) which has recently been delineated by an MDNR study (Vandike, 1992). The recharge area includes portions of the Dry Glaize and Gasconade watersheds (Vandike, 1992). Ha Ha Tonka Spring flows about 1.4 miles to a cove on the Niangua Arm of LOZ. Many karst features and the dramatic faults evident in the vicinity of Ha Ha Tonka Spring suggest that a large underground reservoir may supply the spring (Vineyard and Feder, 1982). In response to concerns about steady increases in nitrates and phosphates in the late 1960s, a thorough study of potential contamination sources in the vicinity of Ha Ha Tonka Spring was conducted (Vineyard and Feder, 1982). To eliminate pollution sources in the vicinity, several nearby resorts were purchased and an extensive sewer system was installed. Several other springs of the Niangua Watershed are hydrologically connected to losing streams outside the watershed (Figure 11).

Losing Streams

Nineteen losing streams have been delineated in the Niangua Watershed (Table 13; Figure 11). A losing stream is a stream segment that loses 30% or more of its flow through permeable geologic materials into a bedrock aquifer. Low flow measurements or dye tracings are used to identify losing stream segments, and the MDNR Water Pollution Control Program maintains a list of identified segments. Wastewater discharges within two miles upstream of a losing stream must meet more stringent effluent limitations due to the potential for groundwater pollution. Thirty additional stream segments within the watershed have been identified as losing streams in recent dye tracings (Vandike, 1992), and are awaiting approval for the MDNR list. In addition, several losing streams have been identified in the spring recharge area that lies outside the watershed (Figure 11).

Impoundments

Eighteen small impoundments are shown in Figure 12. Most of these were included in a database maintained by the MDNR. Impoundments with dams over 35 feet high are required to obtain a permit. However, many of the impoundments recorded in the MDNR database are not that large, and were registered voluntarily. Several additional impoundments over ten acres were located on 7.5 minute topographic maps. Lake Niangua (L010) is the largest impoundment in the watershed (360 acres).

Dam and Hydropower Influences

Two hydropower projects impact the Niangua Watershed. Bagnell Dam was completed in 1931 on the Osage River approximately 31 miles downstream from the mouth of the NR. It is owned and operated by Union Electric Company of St. Louis, MO. The facility has eight turbines with a maximum generating capacity of 215,000 kilowatt (kw). It is normally run as a peak load facility, meaning most of the power

Table 10. Maximum and minimum discharges at continuous record stations within the Niangua Watershed.

Site Number	Station Number	Maximum* Discharge ²	Minimum* Discarge ²	Mean* Discharge ³	10%* Exceeds ⁴	50%* Exceeds ⁴	90%* Exceeds ⁴	Peak Stage (ft.)
		44,700	17	424				
G006	06923250	(10/01/86)	(08/23/93)	(206.0-583.0)	799.0	186.0	33.0	24.4
		14,400	55	180				
G006	06923500	(10/01/86)	(11/13/34)	(93.4-306.0)	306.0	140.0	90.0	11.1
		33,400	6					
G026	06924000	(05/19/43)	(10/05/30)		1,246.4	320.4	141.7	21.8
		2,200						
G024	06925200	(10/12/69)	0		4.3	0.3	0.0	10.8

^{*} Cubic feet per second

⁻⁻ No data available.

¹ Period of record in parentheses.

² Date of record in parentheses.

³ Range in parentheses.

⁴ Flow that is exceeded for given percent of period of record.

Table 11. Flood discharges at select gaging stations within the Niangua Watershed.

Site	Station	Flood	discharge	(ft ³ /s) for i	indicated r	ecurrence	interval i	n years
Number	Number	2-	5-	10-	25-	50-	100-	500-
G034	06923000	201	313	394	505	592	682	911
G026	06924000	11,600	20,500	27,100	35,800	42,600	49,500	66,100
G024	06925200	768	1,200	1,490	1,890	2,190	2,490	3,220

Table 12. Significant springs with reference map, location, average flow, and receiving stream within the Niangua Watershed.

Site Number	Spring Name	Topographic Map	Twp	Rng	Sec	Average Flow (cfs)	Receiving Stream
S001	Allgire Spring	Macks Creek	36	18	08	4.54	Trib to Mill Creek
S002	Barclay Spring	Eldridge West	35	18	12		Barclay Spring Branch
S003	Bennett Spring	Bennett Springs	34	18	01	180.0	Bennett Spring Branch
S004	Blue Spring	Barnumton	38	18	07	4.32	Little Niangua River
S005	Burndt Mill Spring	Climax Springs	38	19	10	1.15	Little Niangua River
S006	Conn Spring	Bennett Springs	35	18	25	4.84	Niangua River
S007	Cullen Spring	Hahatonka	38	17	35	0.76	Racetrack Hollow
S008	Eadsons Spring	Barnumton	38	18	11		Prairie Hollow
S009	Famous Blue Spring	Bennett Springs	35	18	36	2.97	Niangua River
S010	Green Ford Spring	Climax Springs	38	19	27	3.12	Little Niangua River
S011	Ha Ha Tonka Spring	Hahatonka	37	17	02		Niangua Arm
S012	Jake George Springs	Beach	32	19	13		Niangua River
S013	Johnson-Wilkerson Spring	Long Lane	32	19	02		Trib to Niangua River
S014	Jordan Spring	Cross Timbers	38	20	20	.02	Starks Creek
S015	King Spring	Leadmine	36	17	30		Jakes Creek
S016	Mills Spring	Hahatonka	37	18	36		Red Cap Hollow
S017	Mint Spring	Eldridge West	36	18	24		Niangua River
S018	Morrow Spring	Green Bay Terrace	38	17	29	1.09	Niangua Arm
S019	Mosier Spring	Hahatonka	37	07	17		Darby Hollow
S020	Moulder Spring	Green Bay Terrace	38	17	19	.03	Trib to Niangua River

S021	Poe Spring	Barnumton	38	18	09		Prairie Hollow
S022	Sweet Blue Spring	Eldridge West	36	17	30	13.17	Niangua River
S023	Vineyard Spring	Marshfield	31	18	28		West Fork (Niangua R)
S024	Webster Springs	Leadmine	36	18	15		Jakes Creek
S025	Gunter Spring	Beach	32	18	17		Trib to Starvey Creek
S026	Springs?	Niangua	31	18	24		East Fork (Niangua R)
S027	Unknown	Beach	31	18	06		Trib to Givins Branch
S028	Sarah Spring?	Beach	31	18	10		East Fork (Niangua R)
S029	Unknown	Beach	32	18	16		Trib to Starvey Creek
S030	Flowing well?	Macks Creek	36	18	08		Mill Creek
S031	Starling Spring	Green Bay Terrace	38	17	18		Niangua Arm (LOZ)
S032	Indian Spring	Beach	32	18	19		Trib to Niangua River

Union Electric Company of St. Louis, MO. The facility has eight turbines with a maximum generating capacity of 215,000 kilowatt (kw). It is normally run as a peak load facility, meaning most of the power is generated during periods when there is high demand for electricity. Bagnell Dam impounds 55,000-acre LOZ, which includes the lower 21 miles of the NR and lower 10 miles of the LNR. Nearly the entire shoreline of the lake is privately owned. The Niangua and Little Niangua arms are typical of much of the rest of the lake - highly developed with numerous private dwellings and recreational businesses. Because the lake was constructed primarily for hydropower production rather than flood control the magnitude of water level fluctuations is much less than that of nearby COE lakes constructed primarily for flood control. Detailed information regarding LOZ can be obtained from the Lake of the Ozarks Management Plan (Stoner, 1999).

Tunnel Dam was completed in 1929 on the NR (~SM 29) creating 360 acre Lake Niangua, a very shallow impoundment which extends upstream 2.3 miles. The storage capacity of Lake Niangua is 2,650 acre-feet at normal pool elevation (711.5 feet MSL). The watershed of the reservoir is approximately 600 square miles. The project was originally operated by the Missouri Electric Power Company, but Sho-Me Power Corporation of Marshfield, MO, purchased the facility in 1944. The project is licensed by the Federal Energy Regulatory Commission (FERC). The facility has two turbines with a maximum generating capacity of 2,650 kw. It is a run-of-the-river facility and derives head for generation by diverting river flow from Lake Niangua through a tunnel to the power plant. This diversion results in greatly reduced flow in the bypass reach, approximately 6.5 miles of river between the dam and the powerhouse.

The Tunnel Dam project was recently relicensed for 30 years beginning June 1, 1994 by the FERC (1994). Requirements of the relicensing include:

- 1) Minimum flows are to be released in the by-pass reach as follows: 60 cfs during March 15 June 15; 40 cfs the rest of the year, or natural inflow, whichever is less.
- 2) The project will continue to operate run-of-river, but Sho-Me Power Corp. has authorization to operate in a peaking mode under the following conditions: peaking can only occur in July and August; it cannot exceed two hours per day; fluctuations in the reservoir surface elevation cannot exceed 0.5 feet; and the resource agencies must be notified.
- **3)** A continuous-monitoring gage recorder is required in the bypass reach and the sluice gate will be calibrated to indicate discharge level.

In November 1995, the USGS installed a continuous record gage below Tunnel Dam with financial support from Sho-Me Power Corporation. Provisional data supplied by the USGS indicated that between December 5, 1995 and December 4, 1996, the daily mean discharge was below the required minimum on 111 of 356 days. The minimum mean daily discharge of 28 cfs was recorded on two separate days. The measured discharge was below the minimum flow requirement (60 cfs) during the spawning season (March 15 to June 15) on 51 of 93 days in 1996.

Table 13. Losing stream segments within the Niangua Watershed with reference map, location, and length.

Site Number	Stream	Counties	Topographic Map	Length	Legal Start	Legal End
D001	Libby Hollow	Camden	Green Bay Terrace	2.0	SESWSE 15,38N,17W	NESWSW 2,38N,17W
D002	Prairie Hollow	Camden	Barnumton	2.0	NWNWNW 27,38N,18W	NWNENW 14,38N,18W
D003	Racetrack Hollow	Camden	Decaturville Hahatonka	5.5	NENWNW 9,37N,16W	SWSWNW 35,38N,17W
D004	Racetrack Hollow	Camden	Camdenton or Decaturville Hahatonka	1.5	SWSENW 25,38N,17W	SWSWNW 35,38N,17W
D005	Bennett Spring Branch	Laclede Dallas	Bennett Springs	10.8	NENENE 34,34N,17W	SENENE 1,34N,18W
D006	Dogwood Hollow and trib	Laclede	Phillipsburg- Bennett Springs	2.5	NWNWSE 32,34N,17W	NENWNW 21,34N,17W
D007	Trib to Dousinbury Creek	Laclede Dallas	Phillipsburg	3.1	SESWSE 8,33N,17W	SWNWSE 12,33N,18W
D008	Mountain Creek	Laclede	Lebanon- Eldridge West	7.6	NENENW 31,35N,16W	SWSESW 4,35N,17W
D009	Dousinbury Creek	Laclede Dallas	Phillipsburg	2.0	NESENE 18,33N,17W	SWNWSE 12,33N,18W
D010	Trib to Woodward Hollow	Laclede	Lebanon- Bennett Springs	3.8	SESE 1,34N,17W	SENWSE 4,34N,17W
D011	Woodward Hollow	Laclede	Bennett Springs	6.8	SWSENW 11,34N,17W	NWSWNW 6,34N,17W
D012	Woolsey Creek	Laclede Camden	Eldridge East- Hahatonka	10.0	SWSESE 24,36N,17W	SWNENE 36,37N,18W
D013	East Fork	Webster	Beach	1.0	NWNENW 3,31N,18W	SENESW 33,32N,18W
D014	Givins Branch	Webster	Beach	3.6	SWSWNW 1,31N,19W	SESWNW 29,32N,18W
D015	Hawk Pond Branch	Webster	Beach	2.1	NWNENE 35,32N,19W	NWSWSW 19,32N,18W
D016	Niangua River	Webster	Beach	0.4	SENESW 33,32N,18W	SESWNW 33,32N,18W
D017	West Fork	Webster	Beach	0.9	NESWNW 4,31N,18W	SENESW 33,32N,18W
D018	West Fork	Webster	Beach	0.4	NWNWSE 28,31N,18W	NWSENW 28,31N,18W
D019	Trib to West Fork	Webster	Beach	0.5	NESENE 28,31N,18W	SWSWNE 28,31N,18W